NASA Continuity Measurements
ESS Concerns

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NRC Space Science Week
Washington, DC

March 7, 2013

Earth Science Program Strategy

Maintain a **balanced program** that:

- **Advances Earth System Science**
- **Delivers societal benefit** through Applications Development
- **Provides essential global spaceborne measurements** supporting science and operations
- **Develops and demonstrates technologies** for next-generation measurements, and
- **Complements and is coordinated with activities of other agencies and international partners**

Support **Research, Applied Sciences, Technology Development, and E/PO programs**

Continue to fund **operations and routine data products for all on-orbit NASA research missions**

Develop and launch remaining foundational missions: LDCM, GPM, OCO-2

Advance formulation and development of top-priority Decadal Survey and Continuity missions: SMAP (10/2014), ICESat-2 (1/2016), SAGE-III/ISS (8/2014) and GRACE-FO (2017) [OCO-3 (2017), PACE (2020), SWOT (2020), ASCENDS, CLARREO, ERM, studies of other missions]

Continue **execution of the full Venture Class program**

Continue working with NOAA and OSTP to address approaches for **providing sustained, long-term spaceborne measurements**.

Provide significant support to **National Climate Assessment**, **USGCRP**, and **international (CEOS) coordination** activities

ESD Role in Climate studies

ESD Program Focus: Climate Related - NASA 2007-2016 Science Plan

How is the global earth system changing?

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How will the Earth system change in the future?

Among the ESD Science Goals

… Provide satellite based observations

… Study Earth System processes, data assimilation, and modeling to enable improved prediction of climate variability and change, weather, and natural hazards.

NASA ESD Climate Initiative/Architecture, 2010

…. Allows NASA to address important scientific needs for continuity of key climate observations

…. Proposes modeling, assessment, and computing activities to expand NASA's contribution to the 2013 National Assessment by the USGCRP and the next mitigation and adaptation (Working Group II) assessment of the IPCC

…. *Funds NASA's role in providing sustained climate measurements*

Issues for Consideration

Requirements for Earth System Observations exceed the capabilities of any national entity

International Collaboration is essential to obtain the most complete suite of measurements

- Planning is necessary to eliminate duplicative missions and to ensure coverage of the essential measurements

GEOSS/CEOS are major elements in developing implementation plans

- How does CEOS receive advice?

Planning mechanism for a coherent plan is not clear

- NRC is a vehicle for establishing US requirements
  - NASA, NOAA ,USGS
- European model for establishment requirements is different
- Japan and India have a role to play
- Other opportunities: South American contributions
- Role for China undefined

GCOS Observing Systems and Data

The Global Observing Systems Information Center (GOSIC) provides access to data, metadata and information from GCOS and partner observing systems. This page provides an overview of all GCOS-relevant network components and systems, separated by domains:

Atmosphere Surface
Atmosphere Upper-Air
Atmosphere Composition
Oceans
Terrestrial
Space

Space-based component of the WMO Global Observing System
Committee on Earth Observation Satellites (CEOS) - Satellite missions for climate
CEOS Working Group on Climate
Strategic Implementation Task Group
US Organizations: NASA, NOAA, USGS
Science Community Input to this process is through these portals

GCOS Essential Climate Variables

Domain	Essential Climate Variables
Atmospheric (over land, sea and ice)	
Surface:	Air temperature, Precipitation, Air pressure, Surface radiation budget, Wind speed and direction, Water vapour.
Upper-air:	Earth radiation budget (including solar irradiance), Upper-air temperature (including MSU radiances), Wind speed and direction, Water vapour, Cloud properties.
Composition:	*Carbon dioxide, Methane, Ozone, Other long-lived greenhouse gases[1], Aerosol properties.*
Oceanic	
Surface:	Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Current, Ocean colour (for biological activity), Carbon dioxide partial pressure.
Sub-surface:	Temperature, Salinity, Current, Nutrients, Carbon, Ocean tracers, Phytoplankton.
Terrestrial*[*2]	River discharge, Water use, Ground water, Lake levels, Snow cover, Glaciers and ice caps, Permafrost and seasonally frozen ground, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation(fAPAR), Leaf area index (LAI), Biomass, Fire disturbance, Soil moisture[3].

Climate Data Record Requirements

When rspecifying continuity, we frequently refer to missions or instruments

ECV's usually involve measurements from multiple missions and/or multiple instruments

Instruments: VIIRS, ATMS, CrIS, TSI, OMPS, SCAT, ALT, GRACE,...

Measurement: radiometric spectral imaging, time delay, waveform,….

ECV's : SSH, radiance, temperature, color, salinity ,currents, ….

Need requirements for ECV's and mapping from ECV's to Instruments

Suomi NPP Mission

Suomi NPP provides critical data continuity for Earth science research and risk reduction for JPSS instruments, algorithms, ground system, and archive.

Suomi NPP will continue essential climate, weather, and environmental data from polar orbit:

NASA	NOAA
AIRS → CrIS	HIRS → CrIS
AMSU → ATMS	AMSU → ATMS
MODIS → VIIRS	AVHRR → VIIRS
OMI → OMPS	SBUV2 → OMPS
CERES → CERES	

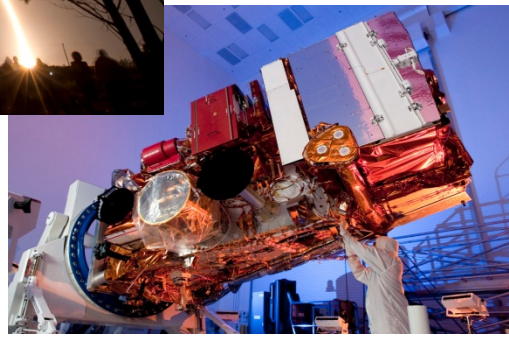
Anticipated Benefits

- Tracking Climate Changes – *measurements to understand climate and the health of our planet*
- A Vigilant Eye on Ozone – *daily measurements to assess recovery of the ozone layer*
- A Sentinel When Disaster Strikes – *wildfires, volcanic eruptions, snowstorms, droughts, floods, hurricanes*
- Watching the Weather – *soundings of atmospheric temperature and moisture, cloud cover*

NPP Instruments

- Visible Infrared Imaging Radiometer Suite (VIIRS)
- Cross-track Infrared Sounder (CrIS)
- Advanced Technology Microwave Sounder (ATMS)
- Ozone Mapping and Profiler Suite (OMPS)
- Clouds and the Earth's Radiant Energy System (CERES)

→ Only CERES has flown in space before, the four other instruments are new designs.



Launched : October 28, 2011

JPSS Issues After NPP

Significant concern over the scientific content of JPSS Measurements

The JPSS 1/2 payload of Scientific Instruments includes:

- Visible/Infrared Imager/Radiometer Suite (VIIRS)
- *Cross-track Infrared Sounder (CrIS)*
- *Advanced Technology Microwave Sounder (ATMS)*
- *Ozone Mapping and Profiler Suite (OMPS)*
- *Cloud and Earth Radiant Energy System (CERES)*
- *Total Solar Irradiance Sensor (TSIS)*

Budget Issues threaten a number of the Instruments on JPSS 1/2

Processing Algorithms for Sensor Data are not clear

- NOAA responsible for requirements
  - Level 1 Processing Documents available
  - Not clear what higher level products will be developed

Calibration/ Validation Issues remain

Example: EOS Data Record Continuity

Primary EOS Objectives: To initiate long term measures of the Earth System designed to detect critical changes, e.g., Climate Data Records

After ~14 yr of EOS data generation, longer term continuity has been assigned to JPSS. Original suite of EOS data products has expanded significantly with new experimental products, but the value of the data products for long-term climate science is variable.

In the international planning around CEOS and GEOSS, general lists of CDRs have been generated. However there has not been a sensor specific, product by product evaluation of which current EOS data products should be prioritized for JPSS .

A review to evaluate current regularly produced data products from the Terra, Aqua and Aura platforms, and explicitly prioritize which data products to continue in the JPSS era.

Summary of Issues and Concerns(1)

Interpreting and predicting climate trends requires measurement continuity, calibration, modeling and data assimilation

- Satellites are only practical way to achieve this global perspective
- Measurement length is more important than improved accuracy

Process studies focus on global, synoptic and continuous measurements for a finite interval

- Emphasis on newer and more accurate measurements

With capped resources, ESD faces a conflict between these needs.

Prioritization for continuing measurements is essential.

Summary of Issues and Concerns(2)

Measurement Continuity Issues

- Which measurements are needed?
- What are their properties?
- Balance between continuity and process studies

Implementation Issues

- International collaboration is required for a complete measurement suite
- Enormous potential in providing climate measurements by improving measurements for operations
- Efforts to transfer measurement continuity for science data records to operational programs have not been successful

A plan is needed to ensure the continuation of important satellite based climate data records

- *Identification of required records*
- *Specification of the measurement properties*
- *Plan for continuation of the required records*
- *Requires integration of interagency and international interest*